## REMARKS ON HOLLOW BRICKS,

AS USED IN THE GREAT ARCH CEILING OVER ST. GEORGE'S HALL, LIVERPOOL, AND ON BRICK AND ARCH CONSTRUCTIONS IN GENERAL.

In the following brief and imperfect remarks, on the peculiar structure of the ceiling of St. George's Hall, I beg to disclaim any pretensions to originality in the matter. My only desire is, to give a plain statement of facts. The use of bricks and tiles, solid and hollow, appears to be as old as the records of history. They are dug from the buried ruins of a forgotten civilization in Asia; the Egyptians converted their manufacture into an intolerable burden to the enslaved Jews; the Etruscans and Greeks were skilled in the art of working clay, to an extent even now considered almost perfect; the Romans constructed vast works with bricks and tiles, moulded into forms of use and beauty, unknown even in this age of invention; and the Italian architects have used bricks and tiles in their buildings, following the examples set them by their Roman predecessors. There are many old examples of brick and tile work where the material has been moulded into forms of ornament as well as utility of construction.

In the fifth and sixth centuries, bricks were used in walls and arches as a facing to rubble and concrete, as seen in the sections given of palaces, churches, and other constructions of the time of Theodoric, at Terracina. The ancient temple of the Caffarella, two miles from Rome, one of the earliest examples of a pagan temple consecrated to the Christian religion in the fourth century, is of brick, and the cornices, which are bold in their projection and elaborate in relief and ornament, are also of brick, and terra-cotta ornaments adorn the structure.

St. Stephen's, the round, at Rome, was ceiled with small vases or tubes of terra-cotta; these tubes were from six to seven inches in length, three inches in diameter, the exterior surface spirally channelled to give greater hold to the mortar. This building was converted from a heathen temple to a Christian church, in the fifth or sixth century.

The church of St. Vitali, at Ravenna, built under the reign of Justinian, and from drawings brought from the East, in the sixth century, has a dome constructed in spiral lines with small terra-cotta vases, seven inches long and two inches diameter, the lower part of the structure being built with vases of terra-cotta twenty-two inches high and eight inches in diameter.

The house of Pilate, at Rome, eleventh century, exhibits a knowledge of construction and adaptation of brick and tile to the purposes of ornament and use, for which we shall look in vain to find many modern examples to compare with it; there is beauty, utility, fitness, and variety combined, so as to give strength and grace to the structure. If we would learn how to construct arches for durability, we must (except in rare cases) most certainly refer to the works of men two thousand years dead and buried. We shall assuredly not find in their great works any examples of flat lintels over openings, with parallel bricks, set in parallel beds, until the courses meet in a point on the under side, leaving a triangular space for the key, which is fitted in with similar parallel courses, and yet this abortion of an arch is the modern mode of construction in too many instances throughout this country; examples of it may be found in new houses and public buildings not six months old; the cement and stucco-fronted shams of modern London have rarely any other form of construction, and the result is exhibited in ugly cracks and rents over the door and window openings.

I would beg to mention, incidentally, that fitness and propriety are not so much considered as they ought to be in the construction of arches for architectural purposes, and I could bring hundreds of examples, even from those termed our finest buildings, to prove this. The purpose of an arch is to span and cover in a space not attainable by horizontal lintels. This may be termed its prime purpose on a great scale, such as in the ceiling immediately under notice; this is only accomplished by a judicious distribution of strength and weight, so as to balance equally all the parts. At the springing line, the arch must be the deepest on bed; at the crown, or key, it ought to be the lightest and thinnest, so that if it was divided along the line of key and erected into a wall on each abutment there would be a gradual diminution of thickness and strength from the base to the summit. I would ask, is this the mode of construction generally used? Do we not see all forms of arch, the semi, the segment, and the elliptical, with a bed at the springing several times less than the depth at the key. Divide such arches, and rear them up on their abutments, and we should have the pyramid on its apex. Then we have faulty jointing; the beds of an ellipsis all drawn to one point, as seen in the arch at Temple Bar; or the inner and outer line is equally divided to produce the bed lines; archstones bent in the form of an *f*, as seen in semi's, &c.

The bent joint, or bed, in masonry ought never to be used. All masonry must depend, principally, up onits gravity, for stability; stones cannot, legitimately, be hung together; they may, however, be joggled for some purposes of strength in their vertical joints and horizontal beds, but no form of arch should depend upon joggles. Stone ought to be considered as having no tensile strength, and be treated and used accordingly. Bricks should be made subject to the same rule.

In bridge-building we frequently see a heavy ponderous key-stone, and over it a break in the cornice, with a massive solid pedestal in an otherwise open balustrade, on which, at times, a lamp is placed. All this is false; the pedestal should be over the pier or abutment, and not over the key, where all should be light and graceful: unbroken lines over an opening always have the best effect; there should be no massing or adding of weight at the crown of an arch.

The bridges of Telford and Rennie display constructive skill of the highest order; Mr. Buck, the engineer, has studied bridge construction thoroughly, and his examples may be considered perfect. Some of his bridges can be seen in Manchester, near the Birmingham and Sheffield Railway Station. The great bridge over the Dee at Chester, designed by the late Mr. Harrison, and constructed by Mr. Jesse Hartley, Engineer of the Liverpool Docks, is one of the finest examples of masonry in the world. Mr. Hartley is perhaps one of the most perfect masons and constructive engineers of the age, of which his Liverpool dock-works are an enduring testimony; he is always perfect in his arrangement of masonry beds and joints. There are also good examples by other architects and engineers.

Columns and architraves, forming the appearance of a door or porch, have no business with the abutments or piers of bridges; they are not useful, and most certainly are not ornamental, and yet we find them added to the finest bridges in the world; some of those over the Thames.

In making these remarks I may be considered bold, and presumptuous; but I must dare the censure in advocating propriety and fitness in construction, and asserting that construction must be the first consideration. If ornament will not harmonize with construction, ornament must give way; if precedent rebels against construction, precedent must be abandoned.

It has been shown from the ancient examples quoted, that the use of hollow bricks, tiles, and terra-cotta vases for arch and dome structures, is at least 2,000 years old, and that some of the work is now perfect; an enduring testimony to the constructive skill of the architects and builders. We may not then claim the honour of invention in the use of hollow brick or tile; but we may follow the example set to us, and, with modern means and appliances, improve upon our models. We have clay in abundance, fuel cheap, tile and brick-making machines to economise labour, &c. There has hitherto been one great drawback to improvement in brick and tile construction, the excise duty. This in a great measure has arisen from an idea that the law dictated the form and size, namely, 10 inches by 5 inches, by 3 inches, or, 150 cube inches. The 150 cube inches the law does dictate as the largest size for single duty; but any form may be given to that cubic capacity; and, if the brick does not displace, in water, more than this number of inches, it will be allowed at the single duty. But even with this relaxation, the law is more fitted for China than for Great Britain, as it cripples invention and cramps construction.

I will now quote some passages, from a MS. volume by Mr. Edwin Chadwick,* on the subject of hollow bricks:—

If we suppose that improvement were to stop at the adoption of constructions of hollow bricks made of the common sizes and shapes, so that they might be worked by the common bricklayers without change of their practice in any other respects, the gain would be considerable in getting rid of a large proportion of the absorbent qualities, and the damp incident to the use of common bricks, apart from the gain in the more economical manufacture of the hollow bricks.

There appears to be no reason to doubt that all the observations which we have collected, in respect to the superior warmth of double walls, and of walls made hollow as described by means of half bricks, of battened walls, and of hollow walls of wainscot, will be found applicable to walls of the proposed hollow brick construction. In reducing the amount of heat requisite to repel extraneous damp, we economise the labourer's fuel, in other words, increase its power and his means of comfort.

Suppose the walls of a cottage constructed 9 inches thick with 9-inch hollow bricks, the possible absorbent power of the walls of a cottage, say of 500 cubic feet, will be reduced from 300 gallons to 102 gallons of water.

Any gentleman who has a tile-machine and a kiln, may with it use almost any description of clay, and more conveniently apply it to the manufacture of hollow than common bricks for the construction of dwellings for his labourers; which dwellings will be drier and warmer, and he may afford to let them at a lower rent than the common cottages.

For farm steadings, also, and for garden walls, the less absorbent and drier walls, constructed with the harder-burnt and less porous hollow bricks, will be found of great advantage.

But the remaining absorbent power of the hollow bricks, it may be submitted, is an ill quality, for the removal of which it is worth while to make exertions. To this end I have requested a trial to be made of a machine, for giving additional density by additional pressure to the bricks made by the machine. The trials are very satisfactory, and the work is promised to be done at a very cheap rate.

I propose to have the bricks glazed, to save whitewashing and paint inside the house, and to give a cheerful appearance on the outside, and to repel the weather. The process, judging by that for pottery, need not be an expensive one. It would, moreover, be worth the while to increase the density of the clay, by a careful preparation of it in the mode of potter's clays.

By the additional pressure, greater exactitude to form will be given, and larger bricks made, fit for a construction of the nature of ashlar or stone construction.

To keep, however, to the construction of walls, there appears to be no reason for supposing that a 5 or 6-inch wall may not be made by means of hollow bricks sufficiently dry and warm, to render any further increase of thickness of little moment, compared with the expense.

In towns, space in houses is of the greatest consequence. There, the space for the houses of the poorer classes may be taken as small and fixed; and this being so, all that can be gained from the thickness of walls, within that fixed area, is gained as breathing space.

Thus, the difference between a 9-inch and 5-inch wall, in a fourth-class two-story house, is about 500 cubic feet, equal to the space for two bed recesses, or one small sleeping room.

The improvement in the manufacture of bricks so as to ensure to a thick wall greater dryness and warmth than to a practically thick wall, is a highly important object.

Hollow bricks, it may be stated, from the experience of hollow walls, will transmit far less sound than solid walls. Partitions may be made of 3-inch hollow brick, which will not only attain this end excellently well, but another,—that of superseding the hollow wooden partitions, which give dreadful facilities for the spread of fires.

In confined space and crowded apartments, the noise and disturbances from the tread of adults (not to speak of children or their noises) is the occasion of much irritation, and, in the cases of sickness, of pain and injury.

To prevent this, and to isolate as far as possible one family from another, and the living rooms from the sleeping rooms, the floors of some of the improved dwellings for the labouring classes at Birkenhead were constructed of brick in flat arches of about 6 feet span. The arches were

* "On the chief evils affecting the health and comfort of the population, which appear to be preventable by improvements in the materials and for the construction of dwelling-houses, more especially of the dwelling-houses for the poorer classes."

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